What does spelunking have to do with ceilings? Spel - what? Spelunking—the exploration of caves. Not much, usually, but if you read on, you’ll find that not all ceilings are Plain Jane horizontals, as some contractors stated when asked whether they had been challenged by any ceiling projects. Luckily, some architects explore outside “the box” concept and give contractors something to scratch their heads over.

“Anything that needs to be framed in a radius with some veneer board over it and then plastered is probably the hardest system to install,” states a Californian, a view echoed by a fellow Californian and probably held by many others. Thomas Engel of Shepherd in California sent in pictures of tricky ceiling work his company has completed. The Dublin Library [Pix 3a] shows framing of a rotunda that was 30 feet up, with a segmented dome lid and radius soffits surrounding, which were chamfered. The challenge was to lay it out so that all areas were backed for the gypsum board installation, and the soffit and light coves were perfectly round as they tied into the dome ceiling.

A Colorado contractor has some words of wisdom for this kind of project: “Drywall soffits or radiuses built out in an area to go
around with ceiling grid can be difficult. You just need to pull enough string lines off the existing area that you can cut around to maintain the straightness. Many people try to hurry by guessing. Experienced guys can just put an eye on it and tell if it’s straight for a little ways, and then they’ll pull a string on an area and make sure that it’s right. But many piecework-type companies cut corners, resulting in sight-unappealing work without true lines.

**STRAIGHT LINES ARE NOT SO EASY EITHER**

“Linear ceilings,” he adds, “always have a degree of difficulty, although I haven’t seen too many linear recently—probably because they are very expensive systems that are expensive to install because they are so complex. You have to put up the carriers, and the panels snap to them. You have filler strips in the middle pans and have to make sure these strips don’t cover the areas for the ventilation.

“One challenge with wood ceilings in remodeling projects is trying to match the color of an existing wood ceiling. Most owners or GCs don’t understand that W light does hit inside surfaces and lightens or darkens them. Then there’s dust and dirt in the air. And in the old days, cigarette smoke would change the color, too. You have to take a piece of the old wood and match it as closely as possible by tinting the stains.”

Another Coloradoan also found a challenge in wooden ceilings, but in this case, a particular system. “On the Pentax building project, we used a Conwood Natural Line linear wood ceiling of maple, which ran wall to wall with a 3/4 inch reveal all the way around. In some places, a single piece of wood ran wall to wall—the walls being radiused to boot.

“Trying to snap the wood under the clips that hold it in place was really difficult. The clips were spring steel that snapped into a groove in the back of the wood. But they weren’t strong enough: half the time, they bent instead of popping down into the groove when you pushed them. We learned to push up at an angle. But once snapped in, you couldn’t move the wood at all.

“To ensure we had the wood correctly positioned before snapping into place, therefore, we cut the wood longer than needed, and then made a scribe out of a piece of the wood and a razor knife...
blade, scribing both radiused ends, and
then cut it. We then used that 3/4 inch
spacer on one end to try to hold the gap
that we needed while we snapped it into
place. The job took us about five times
longer than anticipated. I was not famil-
lar with the linear product and had bid it
in terms of production time like a metal
linear ceiling, so I was way off base. But
it was a beautiful ceiling when done.”

SSSHH!

For an Arkansan, the challenge with one
ceiling was not in complexity of design
but stringent sound-dampening require-
ments: “We installed sound ceilings for
a church group that the project manag-
er lost a lot of hair over trying to seal
everything against noise penetration
into the rooms. They were using the
rooms as recording studios, and when
you consider that ceiling wires transmit
noise from one floor level to the next,
you can see how tricky the job was.

“We isolated the ceiling wires with
brackets that mounted to the deck
above. The mounting brackets had a coil
spring that separated them from the
deck and a rubber damper between the
coil spring and the metal framing that
held the spring in place just above the
ceiling.

We used foam because the wallboard
could not be attached to the wall. We
hung it like a grid ceiling, but butted up
against a piece of rubber so that the
sound couldn’t transmit into the space
above the ceiling line.

The usual rating in decibels for sound
levels permitted to penetrate from one
room to another is 45.0, and we took it
all the way down to 1.0 for that job.
When inside the rooms, you could not
hear anything right outside, even if
someone were knocking on the door or
a window. We had installed special door-
frames, and triple-insulated doors that
weighed 450 pounds (with angled-cuff
hinges to make opening them almost
effortless). The windows, likewise, did
not transmit sound because they were
made of three layers of glass with air
between them.

“Part of the challenge, of course, was
finding qualified guys for acoustical. We
used someone from the office who had
several decades of experience in the field.
You lose your butt over these complex
ceilings projects, sometimes even paying to do them. We try to learn from our mistakes and hopefully make a little bit on the next one. That church ceiling we made nothing on, but we’ll know how to price it better next time!”

THE CAVE CONNECTION

“The most challenging ceiling I have ever worked on is the Founder’s Room at the Disney Concert Hall, where the high-rolling patrons gather prior to a function for drinks.” So states Mark Enquist, project manager at Raymond Interior Systems, Orange, Calif. “Fundamentally, it’s a suspended plaster ceiling, but after that, all the rules changed. The ceiling isn’t flat or horizontal; it goes vertically and then inverts, or rolls over onto itself. The overall effect resembles the inside of a cave. It was designed by Frank Gehry who some say crumpled a piece of paper and said, ‘That’s it!’ I personally believe in the other claim: that he was inspired while caving.

“The ceiling is made up of 22 three-dimensional “surfaces” that stretch from hard edge to hard edge, undulating. They intertwine and climb over each other and do some fun things. They have also been likened to the petals of a partially opened rose as you look upward, which then opens up at about 12 feet above the floor, undulating back to the vertical walls at the perimeter of the room. As you walk into the room, the ceiling is flat for approximately 15 feet, and then starts undulating and rising to a hard edge. Then it vaults up another 30 feet above that. Total height is about 43 feet.”

“Originally, the ceiling was drawn conceptually, using plywood gussets etc., cut on a numerically controlled router—the router tip is in essence the pen, and it cuts lines in a big sheet of plywood instead of drawing them on paper.

“So how does one design and build such a complex ceiling? A computer is a good start. On this job, a computer was used from start to finish.

“The drawings were minimal” Enquist explains, “just for permit purposes. The true model of the ceiling was electronic, and we built the entire ceiling from an electronic file. Gehry was using the CATIA format, common in companies that use numerically controlled equipment to manufacture models for auto industry designs.

“So the first challenge was how to extract the information without purchasing a $30,000 program for this one job. We use Mechanical Desktop extensively for three-dimensional layouts of steel and other components of buildings. So we were able to convert Gehry’s files into a format that Mechanical Desktop could read.

“We had a 1-inch tolerance within the curves of the compound curved ceiling and were suffering on how to create the structure behind it and then end up with our finished surface that was within the tolerance.

“One concept that had been presented to the owners before we came in was a metal stud format, where they would identify all the studs in the ceiling and come up with a profile for each stud, bend it and then tighten everything together somehow. Discussion went...
back and forth from lath and plaster to drywall. But once we had our final design, we said the ceiling had to be plaster, and so it was.

“At that point, we studied the model and investigated some of the methods that people had proposed for manufacture. Five of us in the office brainstormed and came up with the idea of using tube steel, because we could roll-form tube steel and it would be much easier than crimping and bending studs or stretch-forming studs.

“So, we settled on a design that incorporated two-dimensional bending of pipes welded into frames that, when they were all assembled, created the foundation and structure for this ceiling. We were able to create two-dimensional pipe by taking the electronic file and slicing it. Each slice through the surface of the model then created a two-dimensional line.

“Because we had limited access and door height, we sliced the model horizontally at 8-foot segments to create panels that would fit through the doors. So we assembled 4-by-8 panels of 1-inch diameter pipe in our shop and, with the assistance of the computer, were able to number them and coordinate the way they fit into the structure of the steel, so we could then put them all together in the field.

“After slicing the building horizontally in 8-foot increments of elevation, we could define where each panel was going to be created in the horizontal band, so we could then extract each panel from the model. We created a jig in our shop that had two walls and a floor. The jig
represented a point in space so we were able to measure x, y and z coordinates within this jig. Because the jig mirrored a file that we had set up electronically, we could extract the information from the model and orient it into our electronic jig the way we wanted it built into the physical jig. From there, we labeled them surface 1, level A, panel #3, for instance. That’s how we identified where we were in the ceiling.

“We also created coordinates for every corner of each panel in the computer and labeled these coordinates in the shop, providing the coordinate values in a spreadsheet format. Our carpenters then laid out an x-y grid on the floor of the Founders’ Room and had a z-axis from the floor up into space to obtain elevations at 8-foot intervals. With the x-y on the floor, they had a horizontal laser and another laser shooting the z, and where they crossed was exactly where the corner would go. So, we would have a laser shooting at 16 feet, for instance, and then we’d lay out our x/y coordinates all over the floor and start raising them to the 16-foot mark.

“The panels had to be suspended somehow, so we used cable. We created a substructure from the existing large steel members that had been bent to create the arc of the vaulted ceiling. In between those ribs, we welded tube steel horizontally. We had pieces of stud coming off the tube steel into the center of the room to carry the lateral load of the panel, transferring that load back to the structural steel. Then the vertical load was carried by cable—galvanized steel-braided rope like aircraft cable.

“Using the computer again, we were able to establish the profile and coordinate plans for strong backs—steel bands around the room every 4 feet in elevation at 4-foot interval—to reinforce this structure we had created in space. All we had to do, then, was find the elevation of a panel and where it was supposed to orient in space, and attach the vertical pipe in the frame of each panel to the strong-backs with a U-bracket.”

**BUILDING ITSELF**

Enquist continues: “Because the ceiling was three-dimensional and a compound curve, once we had set the first row and started working the second row, we found that the panels almost set themselves. If one corner hit the other corner, the arc across that would match, and the upper points always hit where they were supposed to hit—plus or minus an inch, and we’d push it or bend it, do whatever was required. That was one of the interesting results of the installation that we were hoping for but didn’t expect. We were expecting to have to measure every single corner. As it was, we didn’t have to; we were able to throw these things up and screw them together. We attached them to each other with plates and straps.

“This success bore testament to our three guys who had a very high priority on accuracy with the computer model. They took a couple of months to break it down and create these plans. I am looking right now at three 5-inch binders full of cut tickets for each pipe. We had to bend 2,600 pipes each to a different profile and then assemble them into three-dimensional frames. And then all of those sheets were built down into an architectural set that was about 20 sheets thick of various elevations.

“Because some of the corners were so acute that the 1-inch diameter pipe was
interfering, we used 1/4-inch pencil rods to create the corners. We had all those corners tied off and everything attached to the structure we lathed and then corner-beaded with a plastic-nosed radius down each edge, and took out all the bumps and irregularities to create a nice, smooth ceiling. After that, we scratched it and used a USG gypsum plaster finish.

“The computer was our primary tool. We broke the entire three-dimensional ceiling into a two-dimensional drawing. To help my field understand that drawing, I would take the computer out every once in a while and spin the model around until we could see exactly where a hole, overlap or offset might be. It was a first for me—using a computer as a tool to define what we were building, to determine what studs we needed and where they went and how they were configured in space. We had to know before we built this ceiling that the cables were feeding correctly, because we had very strict structural criteria. The cables were carrying a certain amount of weight and we couldn’t overload the tube steel or the panel, and we had to make sure we had just enough cables etc., etc. That’s why we created a solid model and went to the extent of drawing every stud, strut, cable and connection.

“For me, it was a sculpture. Our plasterers freehanded most of the surface without using screens, so it really was sculpting for them; even though they had a base form to follow, the final surface is all their work,” he says. Reading from an anonymous newspaper article called Taking Pride, Enquist continues: “With Disney Hall almost completed, [name] visited not long ago, climbing scaffolding inside the still unfinished Founder’s Room. The plasterwork on the curved ceiling is so fine that the work of the individual plasterer’s hands is visible. [Name] is thrilled to see the beauty and complexity of the ceiling, that human mark, like a brushstroke on canvas, a project that he was hired to work on 14 years ago, so near to completion.”

Enquist says, “We had expected a certain amount of failure in the panels, but, fortunately, we didn’t experience any that were so far out of dimension that they were unusable.”

**THE USUAL CHALLENGES**

Raymond Interior Systems did run into challenges other than the technical one of building an awe-inspiring ceiling: “We had shift issues as we were running 24/7 for three months, but we were able to keep the information flowing from shift to shift. The 24/7 made coordination among the MEP (Mechanical, Electrical and Plumbing) trades pretty tense. We would make progress at night and they would arrive in the morning and say, ‘Oh no! What have you done!’ Tempers flared sometimes, but we always managed to keep things rolling with communication. Everyone working recognized the value and significance of the project.
“This was a hard job and with the right amount of money, it could be done. But we had to compress it down into an approved budget after extremely competitive bidding. I am not sure we came out ahead, but we didn’t lose money. We were hurt on the overtime, as the project was compressed because HVAC design lost about 1.5 months that cost us in the long run. It was just extremely complex to coordinate all these issues, because the HVAC was running around behind our structure and we had to make sure that it fit within all of this strut work we were installing. We had to have every single strut cut just right—we couldn’t say, ‘Oh, just go ahead, just put it there.’

“We also had restrictions on weight, because this project is built on a parking garage; so we weren’t allowed to have lifts closer than 5 feet to each other, and the room was only large enough to fit three lifts, adding difficulty. Coordinating with the other trades wasn’t so difficult after we became used to modeling in three dimensions.

“We had to scaffold for the plastering, and that was unique because the scaffolding was not a simple straight up with the undulating ceiling. Sometimes it was overhead and sometimes underneath our feet. So we created outriggers for the scaffolding.

“The project ended up not being as difficult as one might think looking at the model: Once we had broken it down into its measurable components, we found everything just flowed. When the model said there was supposed to be a duct there, by golly there was! The wires fed the way they were supposed to.”

The design team made the job easy, but the folks in the field had “a lot left up to them and they were very creative in developing brackets and connection methods, feeding and fishing things through, and I was really pleased with the way they executed the drawings,” Enquist concludes.

Which goes to show, what lies above that glass ceiling is where the real ceiling challenges lie.

About the Author
Steven Ferry is a free-lance writer based in Clear-water, Fla.